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Climatic cooling caused by a major weakening of the geomagnetic field

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The geomagnetic field's impact on climate through the modulation of cosmic ray (CR) flux is a long disputed problem. Its exact effects remain unknown. We carried out a paleoenvironmental analysis based on multiproxy records for five interglacials (marine oxygen isotope stages (MISs) 17, 19, 21, 25 and 31) between 0.7 to 1.1 Ma, and quantitatively evaluated the effect of the geomagnetic field on climate. Our samples come from a sediment core with an extremely high accumulation rate (ca. 50-70 cm/kyr) from Osaka Bay, Japan. The depositional environment of the bay has been strongly affected by glacio-eustatic sea-level changes, and the sediments clearly record the orbital cycles of environmental changes. In MIS 17, 21 and 25, the thermal maximum coincided with the sea-level highstand, as expected from Milankovitch theory. On the other hand, the thermal maxima of MIS 19 and 31 lagged the sea-level highstands by several thousand years. Additionally, cooling occurred at or near the sea-level highstand. The anomalous cooling cannot be caused by insolation changes. MIS 19 and 31 encompass the Matuyama-Brunhes (MB) and Lower Jaramillo (LJ) polarity reversals, respectively. Both cooling events coincided with the paleointensity low associated with the polarity reversals. The cooling interval occurred when the geomagnetic field intensity decreased to less than ca. 40% of present value, and the CR flux increased by more than 40%. The mean annual temperature estimated from pollen fossils using a modern analogue technique shows a cooling of ca. 1-4 degrees C. Despite their relatively low temporal resolution, a number of other paleoenvironmental records suggest a relatively cool climate before the MB and LJ boundaries in the low and middle latitudes. In contrast, ice core records from Antarctica shows no evidence of such a cooling event, and thus the magnetic field/CR effect on climate may not have occurred in polar regions. These results may indicate that the Earth's climate can be affected by the geomagnetic field.

Keywords: cooling, geomagnetic reversal, cosmic ray, paleoclimate, paleoceanography, paleomagnetism